Expeditionary Meteorological Support System – XMET Integration with COAMPS-OS®

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LONG-TERM GOALS

The goal of this project is to provide an advanced capability for the U.S. Marine Corps (USMC) user to leverage a unique in-theater environmental sensor network, in combination with other observations, for meteorological data analysis/fusion and short-term forecasts or nowcasts (0-6 hrs) for aviation operations, and for longer-term weather forecasts (6-48 hrs) in support of mission planning, with an emphasis on mountain meteorology in complex terrain.

OBJECTIVES

The objectives of this project are two-fold: 1) to make the in-theater data available on the classified SIPRNET where users in theater have a larger bandwidth and enhanced connectivity to more easily access the reports; and 2) to develop technology to utilize the in-theater data in meteorological analyses, nowcasts, and forecasts and demonstrate the value added by incorporating the additional data into the operational central-site meteorological prediction systems exercised for Afghanistan.

APPROACH

In response to a USMC 3rd Marine Aircraft Wing Universal Need Statement (UNS) for a remote weather visibility sensor, the Scripps Institution of Oceanography and ONR have developed a unique, innovative, portable, autonomous, surface meteorological sensor package called the eXpeditionary METeorological (XMET) system. XMET is able to reliably collect data and automatically transmit the coded observation reports to a central site using Iridium satellite phone technology. Approximately ten XMET systems have been deployed in Afghanistan in support of aviation operations and Scripps has developed an Internet web site to visualize, archive, and publish the reports.

Report Documentation Page

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14. ABSTRACT
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Naval Research Laboratory (NRL) has developed the operational NRL Atmospheric Variational Data Assimilation System (NAVDAS), the high-resolution Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®) and the COAMPS - On demand System (COAMPS-OS®)[1], which includes a Rapid Environmental Assessment (REA) mode for nowcasting and a Meteorological Quality Control (MetQC) software package for forecast diagnostics. These systems are all running routinely in operational or on-demand mode at the Fleet Numerical Meteorology and Oceanography Center (FNMOC) central-site production center, collocated with NRL's Marine Meteorology Division.

Following the observation data flow, our approach is to develop data processing software to continuously access the XMET reports from Scripps, introduce the reports to the standard operational data streams for further processing and dissemination, securely move the reports from the Internet to the SIPRNET, and provide the USMC users with a replica of the Scripps web site hosted on the NRL SIPRNET site. NAVDAS will be enhanced to utilize the quality controlled XMET reports in combination with other observations for a high resolution two-dimensional scalar analysis of pressure, temperature, humidity, winds, and visibility. NAVDAS XMET analyses will be updated hourly in nowcast mode and the products will also be hosted on the NRL SIPRNET web site. COAMPS-OS will be exercised for Afghanistan using the standard NAVDAS three-dimensional analysis for initial conditions and the forecasts will be evaluated against the XMET observations using an enhanced version of the MetQC package. Initially, the NAVDAS XMET analysis will not be used to initialize COAMPS; however, we plan to integrate the enhanced analysis capabilities with COAMPS in the future. COAMPS forecast products will also be hosted on the NRL SIPRNET web site, including products in Geospatial Information System (GIS) compliant overlays for display using Google Earth.

The scientists involved in this project are Mr. John Cook (NRL), the Principal Investigator, Dr. Keith Sashegyi (NRL), who is developing NAVDAS, and Mr. Mike Frost (NRL), who is developing the data processing and visualization software and coordinating the interaction with the COAMPS-OS development team and the transition with FNMOC. The Scripps team is headed by Dr. Eric Terrill, Director, Coastal Observing Research and Development Center. Mr. John Ertl (FNMOC) collaborates with NRL on the data transition to operations.

WORK COMPLETED

In December 2008 a kick-off meeting was held at NRL Monterey to coordinate the project with ONR, USMC users, Scripps, FNMOC, and NRL; a team meeting was also held at NRL in May 2009 to review progress. Scripps developed data translation software to provide the XMET reports in a modified METAR (Meteorological Aviation Routine) observation format that the FNMOC front-end data processing system can support. A process was developed at NRL to poll Scripps every ten minutes and pull all recent reports. The process introduces the reports to the FNMOC front-end data processing system and utilizes the multi-level security system at FNMOC to move the data to the SIPRNET. The Scripps XMET web site software was transitioned to NRL and integrated into the NRL SIPRNET home page. The software was modified to access high resolution maps available from the National Geospatial-Intelligence Agency (NGA) as a user option. The XMET reports are available on the SIPRNET web site with approximately 25 min latency (at about 15 min after the hour).

[1] COAMPS® and COAMPS-OS® are registered trademarks of the Naval Research Laboratory.

With the XMET METAR reports in the standard FNMOC data processing system, the observations are available in the FNMOC internal database used for further distributing observation data (METCAST). As of this report, a necessary update to the database software has not been distributed by FNMOC, so external users do not yet have access to the data and cannot display the XMET data with the Joint METOC[2] Viewer (JMV); however, the promotion to operations is imminent. Currently (as of Sept. 2009), XMET data are distributed through other channels by FNMOC and received at NRL for processing along with other observation data into "T-files", which are the observation inputs to NAVDAS. Observations in the "T-files" are quality controlled, then converted for analysis into innovation vectors, which are the differences between each observation and the model background (i.e., the previous short-term forecast) at each observation location. These innovations are further processed in COAMPS-OS for use by MetQC in visualizing the differences for model diagnostics.

The NAVDAS data preprocessor has been enhanced to utilize the XMET and other METAR-format data in the creation of the innovation vectors. NAVDAS has also been modified to optionally use a one-hour time interval for collecting observations for an analysis to update the model in addition to the standard six-hour time interval currently used operationally in COAMPS. This modification allows NAVDAS to be used in the REA or nowcast mode to cycle through the observations in near real-time, providing more frequent updates of the atmospheric conditions. Work is ongoing with NAVDAS to provide the high-resolution, near-surface characteristics and develop methods to optimize the use of XMET observations for pressure, temperature, wind, and visibility analyses.

COAMPS-OS was used to configure and run a COAMPS forecast domain for Afghanistan for a limited duration while the data processing integration between NRL and Scripps described above was completed. In the meantime, additional requests by ONR for COAMPS-OS weather and oceanographic support for field experiments were received and the computational resources were temporarily diverted from the XMET project to help fulfill those requests. Our plan is to resume running the Afghanistan area for XMET when the data become available (i.e., with the database upgrade at FNMOC). At that time, our automated data processing software will receive the data from FNMOC and make the files available to use by COAMPS-OS.

Scripps has also modified their software to format the XMET reports in NATO MOBOB (Mobile Meteorological Observing Unit Code) and transmits them to the Air Force, who has incorporated the data in their Joint Air Force and Army Weather Information Network (JAAWIN*)* web site. Use of JAAWIN is the standard practice for users in-theater for accessing their weather observations.

RESULTS

Table 1 lists the measured variables and derived products available in the XMET data stream. These data are encoded into a modified METAR and MOBOB formats by Scripps and made available to NRL and the Air Force on an hourly basis. Figure 1 shows the XMET Internet web site display that was transitioned from Scripps and is now hosted on NRL's SIPRNET web site.

[2] METOC is often used as an acronym for "Meteorological and Oceanographic" in the Navy oceanographic community.

Table 1. Measured variables and derived products produced by the XMET system.

The eXpeditionary METeorological (XMET) System	
Measured Variables	
	Air temperature
	Relative humidity
	Dew point
	Wind speed/direction
	Atmospheric visibility
	Barometric pressure
	GPS time
	GPS latitude/longitude/altitude
	Heading, Course and Speed
	Pitch, Roll angles
	System diagnostics
Derived Products	
	Wind chill
	Heat index
	Altimeter settings
	Sea level pressure
	Pressure altitude
	Density altitude

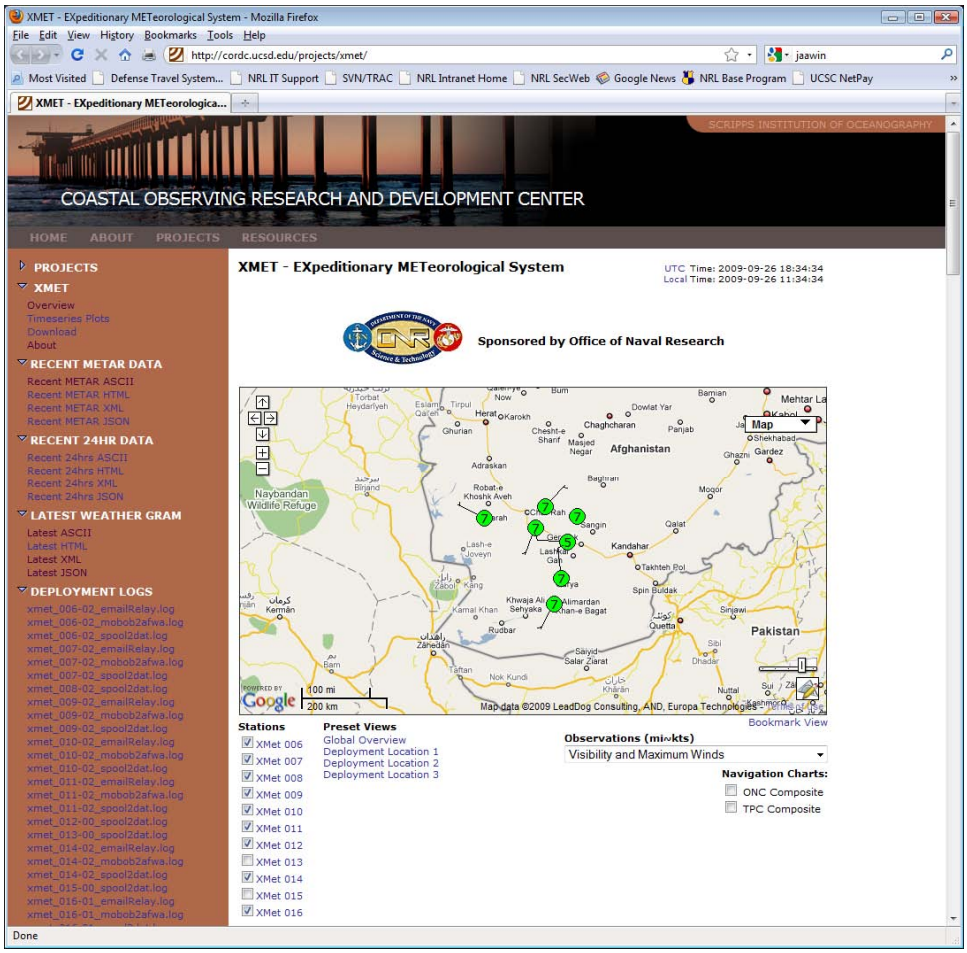


Figure 1. Web browser display showing Scripps XMET Internet web page.

As shown in Figure 2, COAMPS-OS was set up for Afghanistan and run for a trial period. Figure 2 shows the double nest domain and two example aviation products for the 18 km grid spacing inner nest. For this test, COAMPS was configured with two nests: nest 1 – 65x61 grid points at 54 km grid spacing and nest 2 – 79x79 grid points with 18 km grid spacing. The 24 hr forecast took 7 minutes to complete using 32 processors on the NRL 128-processor LINUX cluster.

Figure 3 shows the XMET observations displayed in JMV using the pre-release version of the FNMOC METCAST database. JMV is the Navy standard forecaster toolkit used to develop weather forecasts and briefings from a combination of model gridded data, observations, and satellite data.

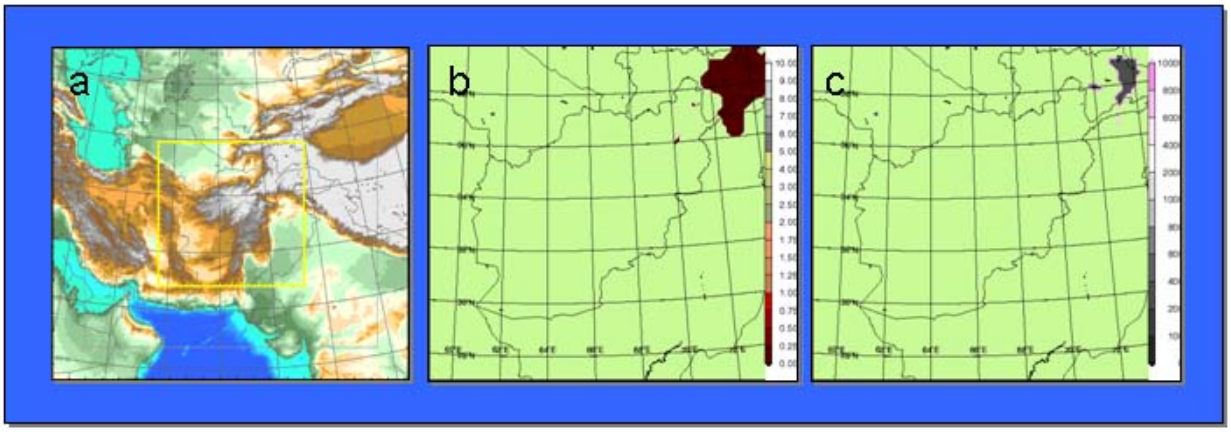


Figure 2. COAMPS map products showing a) the double nest domain (54 km and 18 km grid spacing); b) 24 hr forecast of horizontal visibility (mi) at the surface with low visibilities forecast in the northeast quadrant of the domain; and c) 24 hr forecast of cloud ceiling (ft) with low ceilings forecast for mountains of Tajikistan.

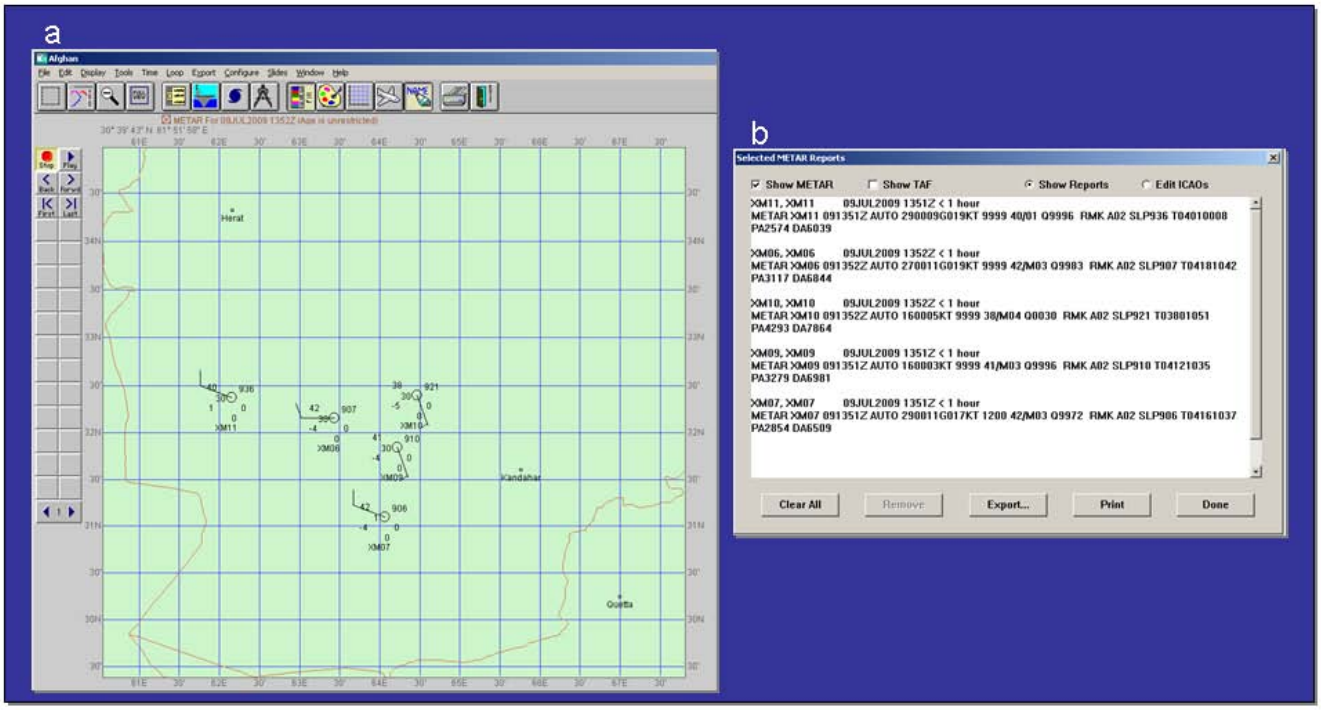
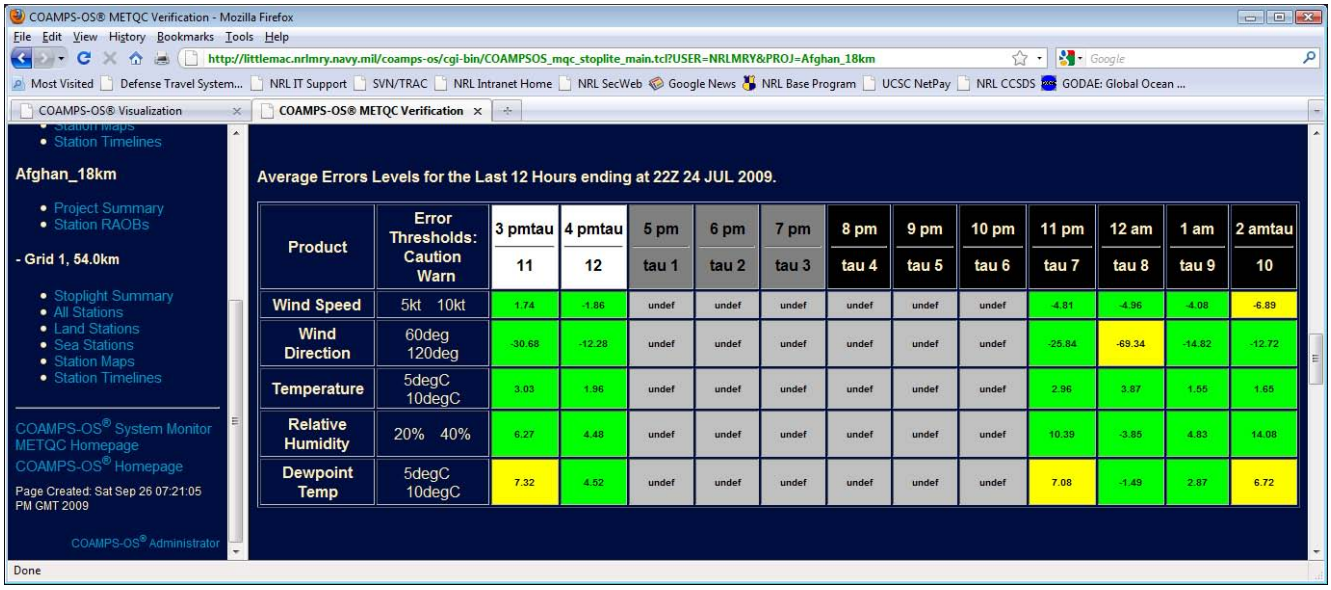


Figure 3. a) JMV map display showing XMET observations from the FNMOC METCAST database and b) JMV detailed XMET observation reports in text format.

Figure 4 is a screen capture of the COAMPS-OS MetQC web page for the Afghanistan project. The model diagnostics data covers the period 10Z to 22Z on 24 July 2009 and shows the average error over the domain between the COAMPS forecasts and the hourly observations from all the surface stations in the domain (25 stations).



Average Errors Levels for the Last 12 Hours ending at 22Z 24 JUL 2009.

Product	Error Thresholds: Caution Warn	3 pmtau 11	4 pmtau 12	5 pm tau 1	6 pm tau 2	7 pm tau 3	8 pm tau 4	9 pm tau 5	10 pm tau 6	11 pm tau 7	12 am tau 8	1 am tau 9	2 amtau 10
Wind Speed	5kt 10kt	1.74	-1.86	undef	undef	undef	undef	undef	undef	-4.81	-4.96	-4.08	-6.89
Wind Direction	60deg 120deg	-30.68	-12.28	undef	undef	undef	undef	undef	undef	-25.84	-69.34	-14.82	-12.72
Temperature	5degC 10degC	3.03	1.96	undef	undef	undef	undef	undef	undef	2.96	3.87	1.55	1.65
Relative Humidity	20% 40%	6.27	4.48	undef	undef	undef	undef	undef	undef	10.39	-3.85	4.83	14.08
Dewpoint Temp	5degC 10degC	7.32	4.52	undef	undef	undef	undef	undef	undef	7.08	-1.49	2.87	6.72

Figure 4 Screen capture of the COAMPS-OS MetQC web page showing the hourly time series summary of average errors in COAMPS wind speed, wind direction, air temperature, relative humidity, and dew-point temperature forecasts compared to all surface meteorological data.

IMPACT/APPLICATIONS

The XMET system helps fill a METOC capabilities gap identified in the USMC UNS for environmental sensing at remote locations, specifically the unattended assessment of surface visibility conditions for aviation operations. The XMET observation data available on the SIPRNET provides situational awareness to METOC forecasters, enabling them to provide more complete information to decision makers who require battlespace environment assessments across the vast and dispersed operational domain. As important and timely as XMET data are, however, they are only available at a small number of locations. Given a few observations, the best tool for obtaining a realistic representation of the atmosphere is a data assimilation system, which continuously updates a short-term model prediction using current data from multiple sources to produce meteorological fields that are consistent with known dynamical and physical relationships. This data assimilation process as it is applied in this project is especially important when forecasting for areas of complex terrain where meteorological observations collected close together spatially may represent very different meteorological characteristics that are varying locally with elevation, topographic features, and land surface type. The enhanced capability provided by this project will significantly improve the user's operational ability to attain and maintain environmental situational awareness within the Afghanistan theater of operations. This enhanced capability will increase the decision maker's ability to assess accurate and time-sensitive environmental intelligence within their decision making processes.

TRANSITIONS

1) Hourly XMET data and the Scripps web page are routinely available to users on the NRL Monterey SIPRNET web site.

2) Hourly XMET data are flowing within the FNMOC infrastructure and will be available shortly to JMV users (via a METCAST database upgrade) for standard METOC forecast applications.

RELATED PROJECTS

This project is one of a few coordinated and inter-related projects at NRL for development of a high-resolution forecasting and nowcasting capability. Related projects include 6.1 Mountain Wave Dynamics (NRL Base), 6.2 Battlespace Environment Assessment for Situational Awareness (NRL Base), 6.2 Advanced Assimilation of Non-conventional Data for Improved High-Impact Weather Prediction (NRL Base), 6.2 COAMPS - Next Generation (ONR), 6.4 Small Scale Models (PMW-120), 6.4 COAMPS-OS (PMW-120), 6.4 Aerosol Optical Product Verification and Validation (PMW-120), 6.4 Mesoscale Observation Impact (PMW-120), 6.4 Atmospheric Data Assimilation (PMW-120), and Ceiling and Visibility Forecast Improvement (FAA).